From Malthusian Stagnation to Modern Growth

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This paper examines the historical evolution of the relationship among population growth, technological change, and the standard of living. It considers several unified models that encompass the transition between three distinct regimes that have characterized the process of economic development: the ''Malthusian Regime,'' the ''Post-Malthusian Regime,'' and the ''Modern Growth Regime.'' We view the unified modeling of this long transition process, from thousands of years of Malthusian stagnation through the demographic transition to modern growth, as one of the most significant research challenges facing economists interested in growth and development.[1]

The analysis focuses on the two most important differences between these regimes from a macroeconomic viewpoint: first, in the behavior of income per capita, and second, in the relationship between the level of income per capita and the growth rate of population. The Modern Growth Regime is characterized by steady growth in both income per capita and the level of technology. In this regime there is a negative relationship between the level of output and the growth rate of population. At the other end of the spectrum is the Malthusian Regime where technological progress and population growth were glacial by modern standards, and income per capita was roughly constant. Further, the relationship between income per capita and population growth was positive. The Post-Malthusian Regime, which fell between the two just described, shared one characteristic with each of them. Income per capita grew during this period, although not as rapidly as it would during the Modern Growth Regime. At the same time, the positive Malthusian relationship between income per capita and population growth was still in place.

The relation between population growth and income was most famously examined by Thomas R. Malthus (1798).[2] The model he proposed has two essential elements. The first is the existence of some factor of production, such as land, which is in fixed supply, implying decreasing returns to scale for all other factors. The second is a positive effect of the standard of living on the growth rate of population. The Malthusian model implies that there exists a negative feedback loop whereby, in the absence of changes in the technology or in the availability of land, the size of the population will be self-equilibrating. More significantly, even if available resources do expand, the level of income per capita will remain unchanged in the long run: better technology or more land will lead to a larger, but not richer, population.

This Malthusian framework accurately characterized the evolution of population and output per capita for most of human history. For thousands of years, the standard of living was roughly constant, and it did not differ greatly across countries. For instance, Angus Maddison (1982) estimates that the growth rate of GDP per capita in Europe between 500 and 1500 was zero. Similarly, population growth was nearly zero, reflecting the slow pace of technological progress. For example, Massimo Livi-Bacci (1997) estimates the growth rate of world population from the year 1 to 1750 at 0.064 percent per year. Fluctuations in population and wages also bear out the predictions of the Malthusian model. For instance, negative shocks to population, such as

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[1] Robert E. Lucas, Jr. (1998) makes a similar point.

[2] Lucas (1998) develops a neoclassical Malthusian model in which households optimize over fertility and consumption.

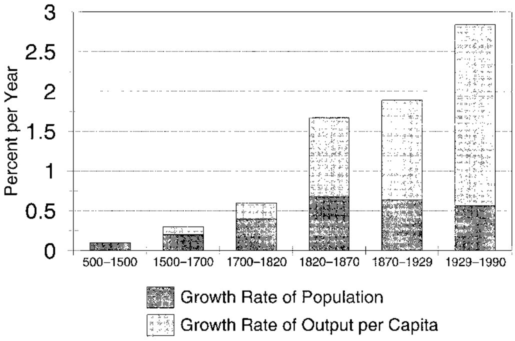

FIGURE 1. OUTPUT GROWTH IN WESTERN EUROPE

the Black Death, were reflected in higher real wages and faster population growth. Finally, the prediction of the Malthusian model that differences in technology should be reflected in population density but not in standards of living is also borne out. Prior to 1800, differences in standards of living among countries were quite small by today's standards. And yet there did exist wide differences in technology.

Ironically, it was only shortly before the time that Malthus wrote that humanity began to emerge from the trap that he described. As Figure 1 shows, the process of emergence from the Malthusian trap was a slow one. The initial effect of faster income growth in Europe was to increase population. Income per capita rose much more slowly than did total output. And as income per capita rose, population grew ever more quickly. Only the fact that output growth accelerated allowed income per capita to continue rising. During this Post-Malthusian Regime, the Malthusian mechanism linking higher income to higher population growth continued to function, but the effect of higher population on diluting resources per capita, and thus lowering income per capita, was counteracted by technological progress, which allowed income to keep rising.

Initially, as living standards rose, fertility increased and mortality fell. Between 1740 and 1840 life expectancy at birth rose from 33 to 40 years in England and from 25 to 40 years in France (Livi-Bacci, 1997). Mortality reductions led to growth of the population both because more children reached breeding age and because each person lived for a larger number of years. Furthermore, the initial effect of higher income was also to raise fertility directly. Fertility rates increased in most of Western Europe until the second half of the 19th century, peaking in England and Wales in 1871 and in Germany in 1875 (Ansley Coale and Roy Treadway, 1986).[3] As income continued to rise, population growth fell. The reduction in fertility was most rapid in Europe around the turn of the century. Furthermore, the reversal of the Malthusian relation between income and population growth corresponded to an increase in the level of resources invested in each child. For example, the average number of years of schooling in England and Wales rose from 2.3 for the cohort born between 1801 and 1805 to 5.2 for the cohort born between 1852 and 1856 and to 9.1 for the cohort born between 1897 and 1906 (R. C. O. Matthews et al., 1982 p. 573 [table E.1]).

The emergence from the Malthusian trap and the onset of the demographic transition raise intriguing questions. How is it that the link between income per capita and population growth, which had for so long been a constant of human existence, was so dramatically severed? And how does one account for the sudden spurt in growth rates?

Historical evidence suggests that the key event that separates the Malthusian and Post-Malthusian regimes is the acceleration in the pace of technological progress, while the event that separates the Post-Malthusian and Modern Growth eras is the demographic transition that followed the Industrial Revolution. The transitions between these three regimes have shaped the world that we live in today, and yet these important transitions are not well understood. In particular, the observation that the demographic transition followed on the heels of the Industrial Revolution does not answer the question of why it has occurred. Would it have been possible for the demographic transition *not* to follow industrialization or for industrialization *not* to precede a demographic transition? And what aspects of the economic

[3] The exception was France, where fertility started to decline in the early 19th century.

environment after the onset of industrialization were responsible for demographic transition?

Neoclassical growth models with exogenous population clearly are unable to capture this intricate transition process. Furthermore, the majority of growth models with endogenous population have been oriented toward the Modern Regime, trying to explain the negative relation between income and population growth either cross-sectionally or within a single country over time (e.g., Robert J. Barro and Gary S. Becker, 1989).[4]

This paper describes several mechanisms that can account for the complexities of these long transitions. The emphasis throughout is on the experience of Europe and its offshoots, since these were the areas that went through the complete transition from the Malthusian Regime to modern growth. In much of the rest of the world, such a transition is incomplete, and it has been influenced dramatically by the import of preexisting production and health technologies.

I. Technological Change and the Return to Human Capital

In Galor and Weil (1998), we develop a unified endogenous-growth model in which the evolution of population, technology, and output growth is consistent with the long transition process described above. The first element of the model is that technological progress raises the rate of return to human capital and hence induces parents to substitute quality for quantity of children. Such an effect would be a natural explanation for the dramatic rise in schooling and the onset of the demographic transition in Europe over the course of the 19th century. The second piece of the model is that the choice of parents regarding the education level of their children has implications for the speed of technological progress. Children with high levels of human capital are more likely to advance the technological frontier. In addition, the size of the population positively influences the growth rate of technology. The final piece of the model is the most classical: as population rises, the land-to-population ratio falls, and the wage falls. When technology is static, then the size of the population is self-equilibrating. But sufficiently rapid technological progress overcomes the land constraint, allowing wages to rise.

In early stages of development the economy is in a Malthusian ''pseudo-steady state'' that is stable over long periods of time. Output per capita is stationary. Technology progresses only slowly and is reflected in proportional increases in output and population. Furthermore, because technological progress is slow, the return to human capital is low, and so parents have little incentive to substitute child quality for quantity.

The impact of population size on the rate of technological progress causes the Malthusian pseudo-steady state to vanish in the long run. At a sufficiently high level of population, the rate of population-induced technological progress will raise the return to human capital sufficiently so as to induce parents to provide their children with some human capital. At this point, a virtuous circle develops: higher human capital raises technological progress, which in turn raises the value of human capital.

Increased technological progress initially has two effects on population growth. On the one hand, improved technology eases households' budget constraints, allowing them to spend more resources on raising children. On the other hand, it induces a reallocation of these increased resources toward child quality. In the Post-Malthusian Regime, the former effect dominates, and so population growth rises along with output growth. Eventually, however, more rapid technological progress due to the increase in the level of human capital triggers a demographic transition: the return to child quality continues to rise, the shift away

[4] A notable exception is Michael Kremer (1993), who provides the first attempt at modeling this long transition. Assuming a simple feedback loop between technology and population, Kremer generates a transition from the proximity of a Malthusian equilibrium to the Post-Malthusian Regime. To generate the demographic transition, Kremer assumes that population growth increases with income at low levels of income and then decreases with income at high levels of income. He argues that this pattern could follow if raising children entails costs both in goods and time, mortality falls with income, and the utility function requires lower bounds on consumption level and the number of children.

from child quantity becomes more significant, population growth declines, and output growth rises.

II. Mortality Decline and Human-Capital Investment

One piece of evidence with which models of fertility dynamics must wrestle is the decline in mortality that has taken place over the process of development. The fact that mortality and fertility have changed at roughly the same time (and that the two of these jointly, via the net rate of reproduction, determine the growth rate of population) has led demographers to view them as components of a single ''demographic transition.'' Obviously, in a Malthusian regime mortality and fertility rates do fluctuate together, so that the net rate of reproduction averages to 1. But there is no reason that this feature of the Malthusian Regime should necessarily be reproduced once subsistence constraints are relaxed.

If households care about their number of *surviving* children, and if they have a target number of survivors, then a reduction in mortality will mechanically lead to a corresponding reduction in fertility. While this story undoubtedly accounts for a significant part of the reduction in fertility, it is incomplete for several reasons. The most interesting problem from an economic point of view is the reduction in *net* fertility (i.e., the number of children reaching adulthood), about which this model of a target number of children is silent.

There are at least two other effects of mortality that can help explain the reduction in net fertility. The first relies on risk aversion. If the marginal utility of a surviving child is convex in the number of survivors, then there will be a ''precautionary childbearing'' effect: the expected number of survivors will fall as mortality (and thus uncertainty) falls. A second effect of falling mortality is that it raises the rate of return on investments in a child's human capital and thus can induce households to make quality–quantity trade-offs. This inducement to increased investment in child quality would be complementary to the increase in the rate of return to human capital discussed in Section I.

Changes in mortality can serve as the basis for a unified model that describes the complete transition from the Malthusian Regime to the Modern Growth Regime. Consider the effect of an initial reduction in mortality (due to an exogenous shock to health technology or to standards of living). If fertility is unchanged, either because households are initially producing fewer surviving children than desired or because of lags in the perception that a reduction in mortality has taken place, population growth will rise. The effect of lower mortality in raising the expected rate of return to human-capital investments will nonetheless be present, leading to more schooling and eventually to a higher rate of technological progress. This will in turn raise income and further lower mortality. At a low enough level of mortality, the effects discussed in the last paragraph will come into play, and net fertility will fall.

III. The Gender Gap and Fertility Transition

In Galor and Weil (1996), we develop a model that is consistent with the Post-Malthusian Regime and the Modern Growth Regime, as well as the transition between them. There are three components to the model: First, economic development decreases the wage differential between men and women. Capital accumulation or technological progress raises women's relative wages, since capital is more complementary to women's labor input than to men's. Second, consistently with empirical evidence, increasing women's relative wages reduces fertility by raising the cost of children more than household income, whereas an increase in male's wages increases fertility due to the pure income effect. And third, lower fertility raises the level of capital per worker.

The incorporation of a fixed factor of production into this basic model generates a unified framework that is consistent with the entire transition process. In early stages of development the economy is in a Malthusian equilibrium. If technological progress is driven initially by the size of population, as population rises and technological progress is sufficiently rapid, the land-to-population ratio falls, but wages may increase nevertheless, permitting further technological progress and capital accumulation. Suppose that in addition to the modern sector, there exists a production technology for producing market goods (presumably at home) in which time spent producing can be partly used for child-rearing. Suppose further that women's marginal product in the home sector is unaffected by technological progress and capital accumulation. As capital and technology evolve, family income increases via the man's wage, while women's wages in the home sector do not change. Fertility increases due to the pure income effect, and the economy is in a Post-Malthusian Regime. However, as the modern sector becomes sufficiently productive, women join the labor force, fertility declines due to the substitution effect, and the economy experiences a demographic transition.

IV. Concluding Remarks

There are obviously other determinants of fertility and growth that have been left out of this discussion, and the elements that we have discussed can also be permuted in various alternative ways. We wish to end, however, by stressing the desirability of building *unified* models of population and development which address not only the demographic transition that occurred in the developed countries over the last century and is currently taking place in much of the rest of the world, but also the Malthusian Regime that characterized so much of human history, as well as the period of rising population growth and output per capita that followed it. Imposing the constraint that a single model explain this entire transition should allow for more complete understanding of the underlying phenomena, better prediction of future trends, and improved analysis of the effects of policy interventions.

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